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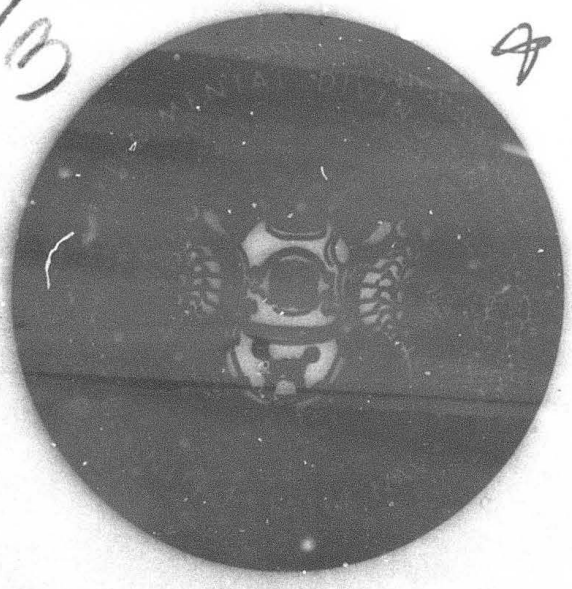

NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

FORMAL REPORT 2-55

CALCULATION OF NITROGEN-OXYGEN MIXED-GAS DECOMPRESSION TABLES

PROJECT NS185-005
SUBTASK 5
TEST 1

19 APRIL 1955

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FOREWORD

Certain research in scuba design is aimed at development of a practical mixed-gas apparatus. Several models of such equipment have been evaluated at the Experimental Diving Unit in the past two years (Formal Reports 4-53 and 13-54; Letter Reports 10-53, 11-53, 12-53, 13-53, 16-53, and 13-54).

Foreseeing the need for new decompression tables to allow maximum utilization of mixed-gas scuba, Bureau of Ships letter S94/1(588) serial 588-885 of 7 April 1953 authorized preparation of theoretical tables and substantiation of those tables by actual dives. Experimental Diving Unit letter A1/ajb serial 104 of 12 June 1953 forwarded the initial project outline. On 18 February 1953 the basic data were given to the Bureau of Ships IBM Computer. Finished tables were returned 20 March 1953.

This is the first formal report for the project although Special Report 9-54 covers much of the basic material. This report includes only a brief of the basic theory, details of the decompression calculations, and tabulation of the theoretical tables. Derivation of oxygen limits and validation of the tables by actual dives will be the subject of future reports for the same project.

ABSTRACT

This report presents a brief of the basic theory of nitrogen-oxygen mixed-gas decompression, and gives the methods used to calculate the theoretical tables.

(1) For each 5% increment from 20% to 60% oxygen.

(2) For 4-minute increments from 0 to 12 minutes of single-stage decompression time.

(3) For 1-minute increments from 15 to 240 minutes of diving bottom time.

Appendix A to the report shows a typical IBM tabulation sheet for the calculations. Appendix B gives the nitrogen-oxygen decompression tables extracted from the IBM tabulations.

The report draws the following conclusions:

(1) The tables should provide adequate decompression.

(2) The tables should be substantiated by a controlled series of dives.

CONTENTS

1. OBJECT

1.1 Objectives

This report has three objectives:

(1) To present a brief of the basic theory of nitrogen-oxygen decompression.

(2) To give the methods used to calculate the theoretical tables.

(3) To formalize the theoretical tables and make them available for experimental evaluation.

1.2 Scope

This report covers only the theory, derivation, and tabulation of decompression data for nitrogen-oxygen mixtures from 20% to 60% oxygen in 5% increments.

2. DESCRIPTION

2.1 General

2.1.1 A complete description of the problem, including the theoretical interrelationship of nitrogen and oxygen effects, appears in Section 9.1 of Special Report 9-54. For convenience, pertinent subsections reappear below.

2.1.2 Three different designations can be applied to a given mixture. The general designation for a nitrogen oxygen mixture specifies the ratio of nitrogen volume percentage to oxygen volume percentage (air is a 79/21 mixture). The other designations for a mixture specify the nitrogen percentage only (air is a 79% nitrogen mixture), or the oxygen percentage only (air is a 21% oxygen mixture). To date, experimental

validation of the tables presented herein indicates that oxygen percentage will always be the primary consideration in the use of gas mixtures. Therefore, although this report deals exclusively with the decompression phase of the calculations, only the specific designation of the oxygen percentage appears throughout this report.

2.1.3 Theoretically, the physiological effect of any gas depends only on its partial pressure, with no regard to the presence of other gases. Consideration of nitrogen-oxygen mixtures for diving requires a careful analysis of the two main physiological effects involved. It is necessary to isolate the effect of high nitrogen partial pressures in order to determine the decompression advantages offered by mixtures, and to isolate the effect of high oxygen partial pressures in order to define the toxicity limits imposed on the use of mixtures. For convenience, partial pressures are expressed in "feet" (of sea water) throughout this report.

2.2 Problem

2.2.1 The necessity for stage decompression after exposure of substantial depth or duration is a factor which seriously limits any type of diving. Maximum utilization of a diver's time under water can occur only when the decompression time is at a minimum.

2.2.2 It is necessary first to determine the decompression required for various nitrogen partial pressure exposure times and second to convert the partial pressures into depth-time limits for different mixtures.

2.2.3 Subsequent tabulation of the decompression required for various combinations of depth, time, and oxygen percentage will simplify comparison of advantages offered by various mixtures and will permit easy correlation of oxygen toxicity limits.

2.3 Approach

2.3.1. Since the need for decompression arises from exposure to increased partial pressures of nitrogen, the necessity can be reduced by using breathing media which contain less nitrogen and more oxygen than air. This approach to the problem works well up to the point at which the partial pressure of oxygen in the mixture reaches toxic levels.

2.3.2 The U.S. Navy Standard Air Decompression Table provides a substantial body of data from which the necessary information about the decompression aspects of mixed-gas diving may be derived. In particular, at depths between 40 and 130 feet the table specifies the durations of exposure which are permissible without decompression stops on ascent, provided that the rate of ascent does not exceed 25 feet a minute. When plotted graphically, these depths and times form a "zero-decompression curve" representing the depth-time relationships for dives which do not require stage decompression. This curve, shown in Figure 1, represents the zero-decompression limits for the most common of all mixed gases: air Decompression requirements are assumed to be dependent only upon the duration of exposure and the partial pressure of the inert gas involved. Therefore the zero-decompression diving time for any depth on air is also the zero-decompression exposure time for the corresponding nitrogen partial pressure. This nitrogen partial pressure for a given mixture at any specified depth can be determined by a simple mathematical transformation. This involves only conversion of the diving depth to "absolute depth" and multiplication of this value by the nitrogen percentage decimal for the mixture, as shown in the following formula:

$$N = (1 - x)(D + 33) \quad (1)$$

Where N = partial pressure of nitrogen, feet of sea water
X = decimal percentage of oxygen in the breathing mixture (0.21 for air)
D = diving depth, feet of sea water
(33 = one atmosphere, in feet of sea water)

2.3.3 A curve of zero-decompression diving times in terms of partial pressures of nitrogen can be obtained simply by converting the various depths of the zero-decompression curve for air into the corresponding partial pressures of nitrogen. Using 0.21 for "X" in Formula (1) gives the curve shown in Figure 2. This curve can give the zero-decompression diving time for any nitrogen-oxygen mixture, when the mixture nitrogen percentage and the depth are known. Formula (1) yields the value of the nitrogen partial pressure in the mixture, and the graph gives the diving time for that value.

2.3.4 For given mixtures, it is simpler to use depth-time curves which can be entered directly with the diving depth. A restatement of Formula (1) allows translation of the zero-decompression nitrogen partial pressure curve into a depth-time curve for any specific mixture.

$$D = (N/(1 - x)) - 33 \quad (2)$$

where the symbols are those defined for Formula (1).

2.3.5 From the standpoint of scuba diving, either with air or with nitrogen-oxygen mixtures, one useful approach to exposures which require decompression would be to have corresponding curves for stated decompression times (as for 4-,8-, or 12-minute stops at the 10-foot stage). With such curves, a diver who could not expect to complete his work within the zero-decompression time could readily determine how much additional time he could gain by planning, for example a 4-minute

decompression stop (at 10 feet) on ascent. In their present form, the tables have large gaps between various "bottom times", and a man who overstays zero-decompression time even by a minute often has no safe alternative but to take prolonged decompression. Curves for specific amounts of decompression are not derived from the standard air table so readily as the curve for zero-decompression, because the table does not present uniform increments of bottom time or of decompression time. The derivation of diving-time curves for various increments of decompression involves construction of cross-curves of decompression time against diving time for the various stated depths. These curves must then be interpolated to yield curves of time against depth (comparable to the zero-decompression curve) for various stated decompression times. This process yields curves for air, but converting these to curves for partial pressure of nitrogen is simply a matter of computation using Formula (1). Further conversion to depth-time curves, similar to Figure 3, is accomplished by use of Formula (2).

3. PROCEDURE

3.1 Zero-decompression tables

3.1.1 For zero-decompression diving, the U.S. Navy Standard Air Decompression Table gives the depth-time limits listed in table 3-1.

3.1.2 When converted by the method given in 2.3.2, the depth points in table 3-1 yield the nitrogen partial pressure limits shown in table 3-2.

3.1.3 Established from table 3-2, the points given in table 3-3 formed the basis of a gross curve for graphical determination of faired values. Note that the 40-minute point is an interpolated value, and that the 240-minute point is 10 feet less than the nitrogen partial pressure in two atmospheres of air.

3.1.4 The gross curve gave the values listed in table 3-4, which in turn formed the basis of a fine curve for determination of the minute-by-minute points for the IBM computer.

TABLE 3-1

AIR DEPTH feet	DIVING TIME minutes
130	15
120	18
110	20
100	25
90	30
80	35
70	43
60	55
50	78
40	120

TABLE 3-2

NITROGEN PARTIAL PRESSURE FEET	EXPOSURE TIME minutes
128.8	15
120.9	18
113.0	20
105.1	25
97.2	30
89.3	35
81.4	43
73.5	55
65.6	78
57.7	120

TABLE 3-3

NITROGEN PARTIAL PRESSURE feet	EXPOSURE TIME minutes
128.8	15
113.0	20
94.7	30
83.8	40
73.5	55
65.6	78
57.7	120
42.1	240

TABLE 3-4

NITROGEN PARTIAL PRESSURE feet	EXPOSURE TIME minutes	NITROGEN PARTIAL PRESSURE feet	EXPOSURE TIME minutes
128.8	15	56.0	130
113.0	20	54.3	140
94.7	30	52.9	150
83.8	40	51.4	160
76.8	50	50.2	170
71.9	60	49.0	180
68.2	70	47.8	190
65.3	80	46.6	200
63.0	90	45.2	210
60.9	100	44.1	220
59.1	110	43.0	230
57.7	120	42.1	240

3.2 Decompression tables

3.2.1 The U.S. Navy Standard Air Decompression Table gives the single-stage decompression times listed in table 3-5 for the depth-time combinations indicated. Note that for depths beyond 130 feet the zero-decompression times are those given in the Surface Decompression Air Table.

TABLE 3-5

DEPTH feet	DIVING BOTTOM TIME (minutes)	DECOMPRESSION TIME AT 10-FOOT STOP (minutes)												
		0	2	4	5	6	7	9	11	12	13	25	32	35
40		120	180	240		300								
50		78	120		150			190		300				
60		55	75								110			
70		43		60										
80		35				50								
90		30				45								
100		25								40				
110		20								35				
120		18							30					
130		15												
140		13		15										
150		11					15							
160		9						15						
170		7							15					
185		-										15		
200		-											15	
210		-												15

A plot of these single-stage decompression times against the corresponding diving time for each diving depth gives the family of equal-depth curves shown in figure 4.

3.2.2 Cutting across the equal-depth curves at single-stage decompression times of 4,8, and 12 minutes gives the depth-time values listed in table 3-6. The corresponding partial pressure points given in the same table formed the basis for gross curves similar to the curve described in 3.1.4. Table 3-7 gives the initial values for these curves. Table 3-8 gives the faired values, which in turn formed the basis for fine curves similar to the curve mentioned in 3.1.4.

Table 3-6

DEPTH feet	DIVING BOTTOM TIME (minutes)	SINGLE-STAGE DECOMPPESSION (min.) 4	8	12	Partial Pressure feet
50		130	180	300	65.6
60		81	94	105	73.5
70		60	67	74	81.4
80		45	54	60	89.3
90		40	47	48	97.2
100		30	37	40	105.1
110		25	32	35	113.0
120		22	28	31	120.9
130		19	23	26	128.8
140		15	19	22	136.7
150		-	16	19	144.6
(155		-	15	-	(148.6)
160		-		17	152.5
170		-		16	160.4

TABLE 3-7

DIVING TIME minutes	SINGLE-STAGE DECOMPRESSION (min.) 4	8	12	PARTIAL PRESSURE (feet)
15	136.7	148.6	161.0	
20	123.0	134.0	141.7	
25			129.2	
30	105.1	115.0	119.2	
40	93.7		105.1	
45	89.3	96.3		
60	81.0	85.0	88.5	
75	75.0			
80			79.4	
90		74.0		
120	63,0			
180	53.8			
240	47.0	50.0	52.0	

TABLE 3-8

DIVING TIME minutes	SINGLE-STAGE DECOMPRESSION (min.) 4	8	12	PARTIAL PRESSURE (feet)
15	136.7	148.6	161.0	
20	123.0	134.0	141.7	
30	105.1	115.0	119.2	
40	93.3	101.1	105.1	
50	86,5	92.6	97.3	
60	81.2	85.2	88.5	
80	73.2	77.0	79.4	
100	67.4	71.0	73.5	
120	62.8	66.4	68.8	
150	57.8	61.2	63.4	
180	53.6	57.0	59.2	
210	50.1	53.2	54.3	
240	47.0	50.0	52.0	

3.3 IBM computer calculations

3.3.1 For basic data, the IBM computer used the minute-by-minute points obtained from the faired values of the fine curves corresponding to tables 3-4 and 3-8. Table 3-9 gives the faired values at 10-minute intervals of diving time for 0,4,8,and 12-minute decompression.

3.3.2 From these basic data, the IBM computer calculated a set of decompression tables for each of the following conditions, using the procedure given in 2.3.4.

(1) For 5% increments from 20% to 60% oxygen.

(2) For 4-minute increments from 0 to 12 minutes of single-stage decompression time.

(3) For one-minute increments from 15 to 240 minutes of diving bottom time.

TABLE 3-9

DIVING TIME minutes	SINGLE-STAGE DECOMPRESSION (minutes) 0	4	8	12
15	128.8	136.7	148.6	161.0
20	113.0	123.0	135.7	141.4
30	94.8	104.3	115.0	119.2
40	83.8	93.5	101.3	105.1
50	76.7	86.5	92.5	96.2
60	71.9	81.3	85.3	89.1
70	68.2	76.9	80.7	83.7
80	63.5	73.2	77.0	79.4
90	63.0	70.1	73.8	76.1
100	61.0	67.5	70.9	73.3
110	59.2	65.2	68.6	71.0
120	57.5	63.2	66.4	68.9
130	55.9	61.1	64.6	66.9
140	54.3	59.4	62.9	65.2
150	52.9	57.8	61.2	63.4
160	51.5	56.3	59.8	61.8
170	50.2	54.8	58.3	60.2
180	49.0	53.5	56.9	58.9
190	47.7	52.2	55.6	57.7
200	46.5	51.1	54.3	56.4
210	45.3	50.0	53.2	55.2
220	44.2	49.0	52.1	54.1
230	43.1	48.0	51.0	53.0
240	42.1	47.0	50.0	52.0

NITROGEN PARTIAL PRESSURE (feet)

4. RESULTS

4.1 Tabulations

The IBM computer tabulated the calculations on standard IBM sheets, which BuShips Code 223 obligingly bound and titled as a working manual. Because the actual tabulations are extremely voluminous, they are not included in this report. Appendix A shows a typical tabulation sheet, and explains it briefly. The Experimental Diving Unit is keeping the original tabulations on hand until the mixture tables have been fully validated.

4.2 Nitrogen-oxygen decompression tables

Appendix B gives the nitrogen-oxygen decompression tables extracted from the IBM calculator tabulations.

5. DISCUSSION

Adequacy of the tables rests mainly on the validity of the hypothesis that inert gas partial pressure exposure time is the only factor leading to the necessity for decompression. From past studies with air and with helium mixtures, the hypothesis seems sufficiently valid to be acceptable here.

A secondary consideration is the accuracy of the calculations. If the computations had been manual there could be many errors throughout the tabulations. Since the computer checked itself continuously, however, the results are very reliable.

In fairing the various curves, all questions were resolved on the side of safety. Consequently the basic data used by the computer were at least as safe as the U.S. Navy Standard Air Table, and generally more so.

One consideration which actually adds a safety factor to the decompression is the use of a high-oxygen breathing medium for the decompression times indicated. Basically, these times are for breathing air during decompression from the partial pressure exposures. Breathing higher oxygen mixtures during decompression theoretically increases the nitrogen washout, reducing the time required for decompression. Since the decompression time does not actually change, however, the result is a net gain in safety.

6. CONCLUSIONS

Until they are substantiated by actual dives, the tables can not be considered unquestionably satisfactory. The following conclusions apply at present.

(1) On a basis of hypothetical conditions, the tables should provide adequate decompression.

(2) The table should be substantiated by a controlled series of dives which account for the corresponding oxygen limits.

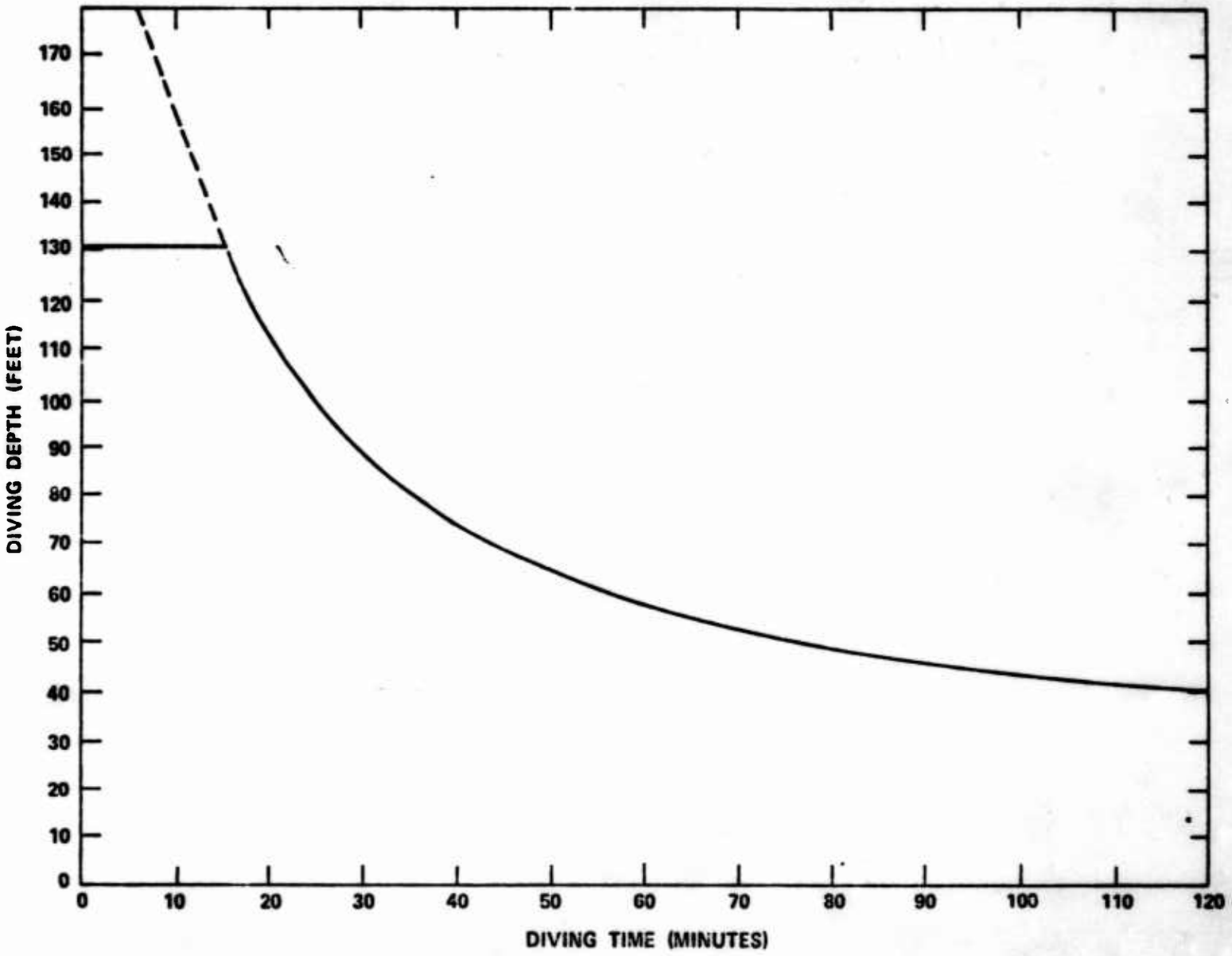

DIVING DEPTH (FEET)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
DIVING TIME (MINUTES)

FIGURE 1

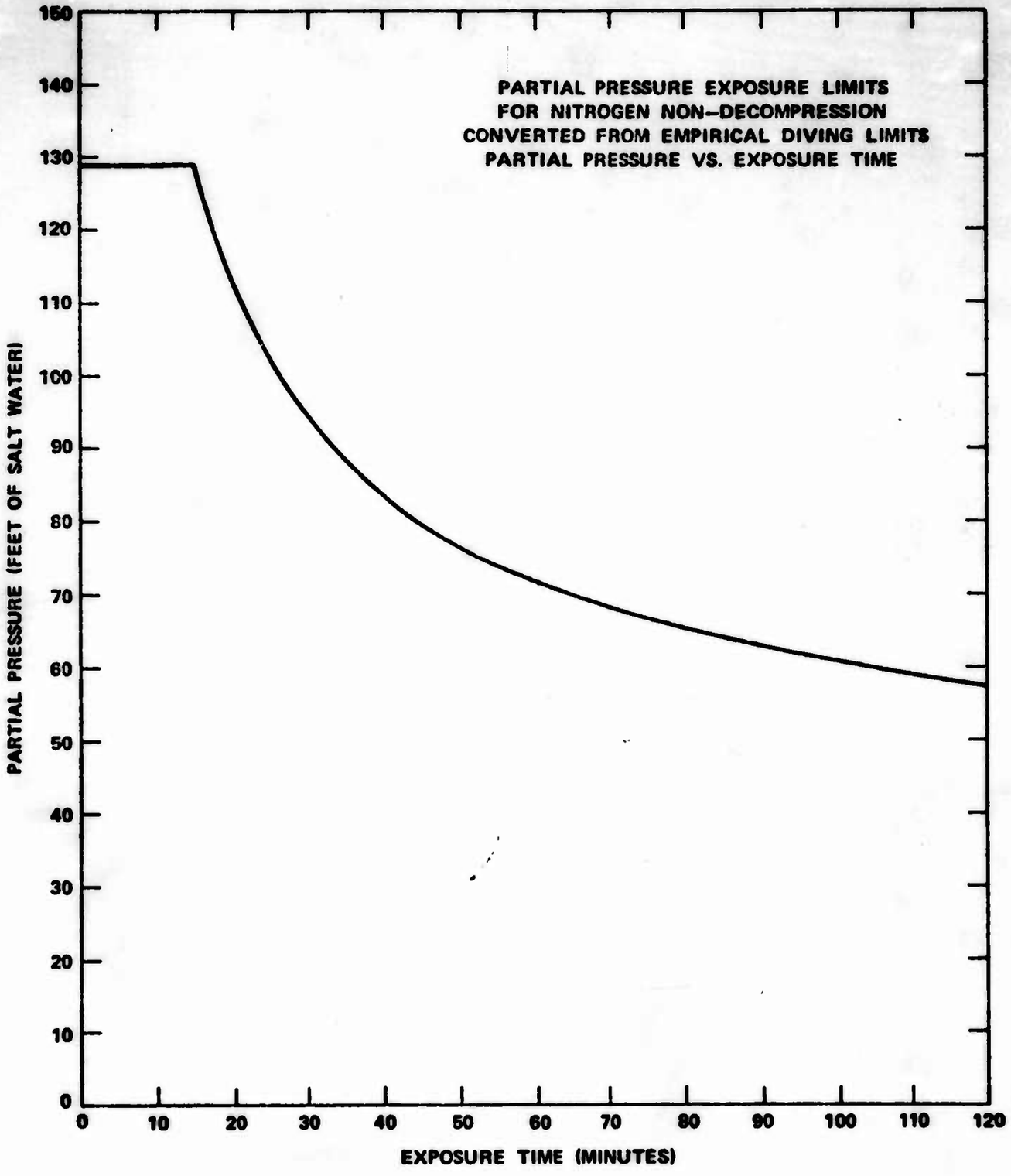
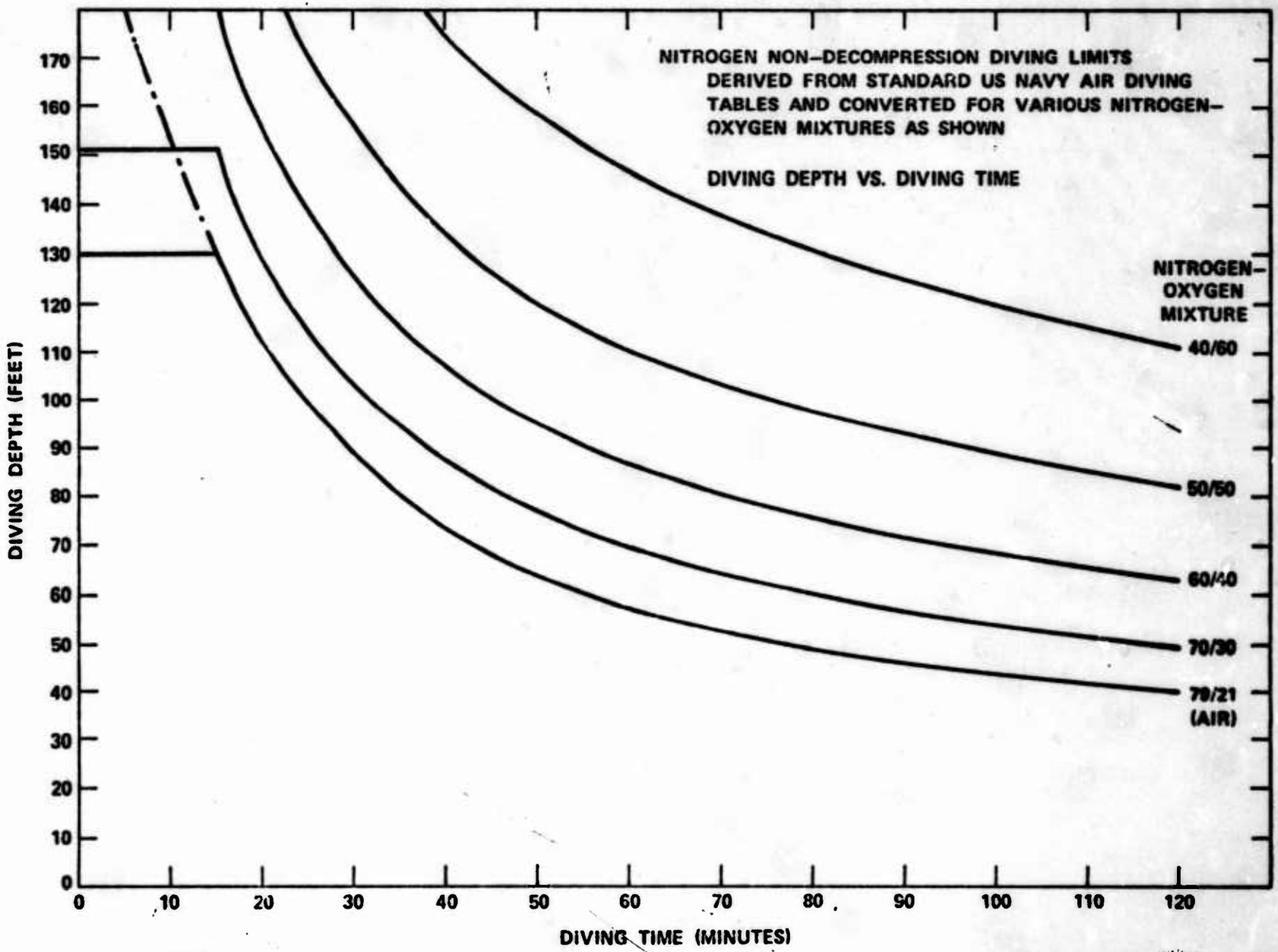


FIGURE 2

J. V. DWYER LCDR USN
EXPERIMENTAL DIVING UNIT
BY HGH 18 APRIL 1955



UNCLASSIFIED NAVPERS 303380–140
FIGURE 3

J. V. DWYER LT. U.S.N.
EXPERIMENTAL DIVING UNIT
BY C.R.K. 29 DECEMBER 1953

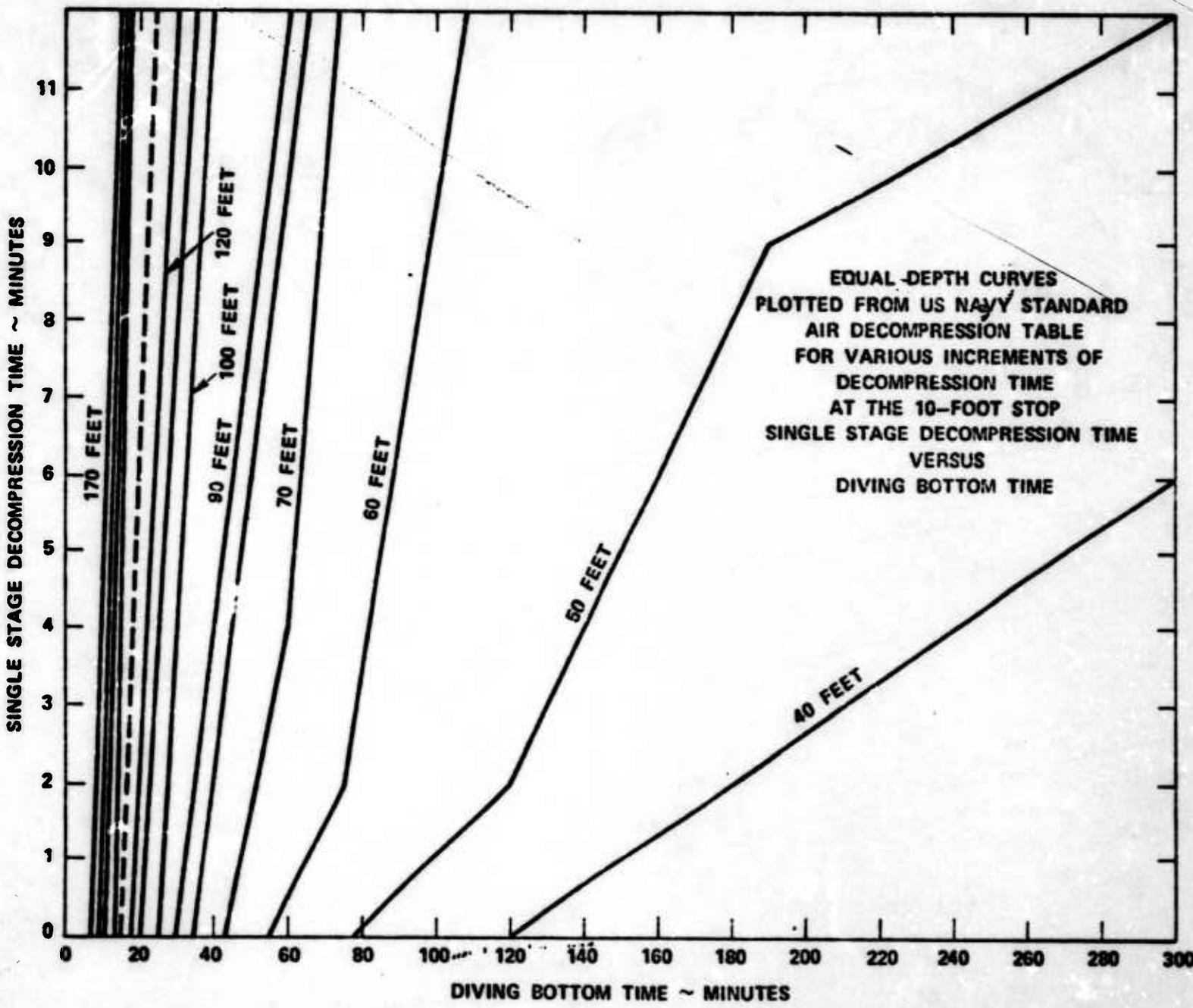


FIGURE 4

H. G. HENLEY DMSN
EXPERIMENTAL DIVING UNIT
19 APRIL 1955

APPENDIX A

SAMPLE IBM TABULATION SHEET

This sheet shows the presentation of the minute-by-minute exposure time limits as calculated for mixed-gas decompression by the Bureau of Ships IBM computer. The particular sheet shown is a set of calculations for exposures to 65% nitrogen followed by 8 minutes of decompression at the 10-foot stop.

The column headed "X" shows the allowable exposure time in minutes. The column head "Y" shows the corresponding depth of exposure on a 65/35 nitrogen-oxygen mixture (35% oxygen). The column headed "Y" shows the partial pressure in a 65% nitrogen mixture at the depth of exposure. The column headed " Y" shows the difference between the indicated partial pressure and the preceding partial pressure, and serves to check the "fairness" of the partial pressure curves.

On the sample sheet the even 10-foot increments of depth are inserted paired with the next higher value given in column "Y". The corresponding diving times are boxed in column "X". This pairing procedure was used throughout the tabulations to obtain the depth-time limits given in Appendix B. If the value in column "Y" was exactly an even 10-foot increment, the next higher value was selected in every case.

The values indicated on the sample sheet appear in Table 4 of Appendix B.

NITROGEN 8 MIN DECOMPRESSION

CURVE FAMILY
on 65 PER CENT CURVE

	Y		X	$\bar{Y}$		$\Delta\bar{Y}$	
	195	6	15	148	6	148	6
190	191	6	16	146	0	2	6
	187	5	17	143	3	2	7
180	183	6	18	140	8	2	5
	179	6	19	138	2	2	6
	175	8	20	135	7	2	5
170	172	1	21	133	3	2	4
	168	6	22	131	0	2	3
	165	2	23	128	8	2	2
160	161	8	24	126	6	2	2
	158	4	25	124	4	2	2
	155	2	26	122	3	2	1
	152	3	27	120	4	1	9
150	149	5	28	118	6	1	8
	146	7	29	116	8	1	8
	143	9	30	115	0	1	8
140	141	3	31	113	3	1	7
	139	0	32	111	8	1	5
	136	6	33	110	2	1	6
	134	4	34	108	8	1	4
	132	4	35	107	5	1	3
130	130	4	36	106	2	1	3
	128	4	37	104	9	1	3
	126	7	38	103	8	1	1
	124	7	39	102	5	1	3
	122	9	40	101	3	1	2
120	121	2	41	100	2	1	1
	119	8	42	99	3		9
	118	3	43	98	3	1	0
	116	9	44	97	4		9
	115	5	45	96	5		9
	114	3	46	95	7		8
	113	0	47	94	9		8
	111	8	48	94	1		8
110	110	6	49	93	3		8
	109	3	50	92	5		8
	108	1	51	91	7		8
	106	9	52	90	9		8
	105	5	53	90	0		9
	104	4	54	89	3		7
	103	5	55	88	7		6
	102	4	56	88	0		7
	101	3	57	87	3		7
100	100	4	58	86	7		6
	99	3	59	86	0		7
	98	3	60	85	3		7
	97	3	61	84	7		6
	96	6	62	84	2		5
	95	9	63	83	8		4

APPENDIX B

THEORETICAL NITROGEN-OXYGEN MIXED-GAS DECOMPRESSION TABLES

The tables given herein cover the theoretical bottom times allowable at the depths from 40 to 200 feet for exposures to oxygen-rich mixtures when followed by various single-stage decompression times. Tables 1 through 9 extend from 20% to 60% oxygen in 5% increments, followed by a special table for 21% oxygen (table 10), which applies to dives on air.

The tables are self-explanatory except for the blanks. Exposure times less than 15 minutes are not considered, so that it is necessary to select the limit corresponding to the next higher increment of decompression time. Exposure times more than 240 minutes are not considered either.

Substantiation of these tables is still in progress. Although the decompression data appear sound, difficulties with oxygen tolerance have not yet been eliminated. It is mandatory to withhold application of these tables until the interrelated studies have been completed.

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 1
20% OXYGEN

showing bottom time in minutes at various depths to 160 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes) 0	4	8	12
40	114	146	169	183
50	75	104	119	132
60	54	76	87	95
70	41	57	65	72
80	33	44	52	57
90	27	34	42	47
100	22	28	35	38
110	19	23	30	32
120	16	20	25	28
130		17	22	24
140			18	21
150			15	18
160				16

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 2
25% OXYGEN

showing bottom time in minutes at various depths to 180 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes)			
	0	4	8	12
40	137	170	196	214
50	93	124	143	157
60	65	91	104	115
70	49	69	79	86
80	38	53	60	67
90	32	41	50	55
100	26	33	41	45
110	22	28	35	38
120	19	23	30	32
130	16	20	26	28
140		17	22	24
150			19	21
160			16	18
170				16
180				15

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 3
30% OXYGEN

showing bottom time in minutes at various depths to 190 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes)			
	0	4	8	12
40	163	199	228	-
50	116	148	171	185
60	80	110	126	140
70	59	83	95	104
80	46	64	73	80
90	37	50	58	65
100	31	40	49	53
110	26	33	41	45
120	22	28	35	38
130	19	24	30	33
140	17	20	26	28
150	15	17	23	25
160		15	20	22
170			17	19
180				17
190				15

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 4
35% OXYGEN

showing bottom time in minutes at various depths to 200 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes)			
	0	4	8	12
40	192	235		
50	142	176	203	221
60	103	133	155	163
70	74	102	117	129
80	56	79	90	99
90	44	62	71	78
100	37	50	58	64
110	31	40	49	54
120	26	33	41	45
130	23	28	36	39
140	20	25	31	34
150	17	21	27	30
160	15	19	24	26
170		16	21	23
180			18	21
190			16	18
200				17

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 5
40% OXYGEN

showing bottom time in minutes at various depths to 200 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes) 0	4	8	12
40	222			
50	172	211	240	
60	130	162	187	204
70	95	126	146	159
80	71	98	113	125
90	55	78	89	97
100	44	62	72	78
110	37	50	59	65
120	32	42	50	55
130	27	35	43	47
140	24	30	37	41
150	21	26	33	36
160	18	23	29	32
170	16	20	26	28
180	15	18	23	25
190		15	20	23
200			18	20

APPENDIX B

THEORETICAL NITROGEN-OXYGEN MIXED-GAS DECOMPRESSION TABLES

TABLE 6
45% Oxygen

showing bottom time in minutes at various depths to 200 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes) 0	4	8	12
50	207			
60	163	199	228	
70	125	157	182	197
80	94	124	144	157
90	71	99	114	126
100	57	80	91	100
110	46	65	75	82
120	39	54	62	69
130	34	45	53	59
140	29	38	46	51
150	26	32	40	44
160	22	28	36	39
170	20	25	32	34
180	18	22	28	31
190	16	20	25	28
200	15	17	23	25

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 7
50% OXYGEN

showing bottom time in minutes at various depths to 200 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes)			
	0	4	8	12
60	199			
70	159	196	224	
80	126	158	182	198
90	97	127	148	161
100	75	103	119	131
110	61	85	97	107
120	50	70	81	88
130	42	58	67	74
140	37	49	58	64
150	32	42	51	56
160	28	36	44	49
170	25	32	39	43
180	22	28	35	38
190	20	25	32	34
200	18	22	29	31

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 8
55% OXYGEN

showing bottom time in minutes at various depths to 200 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes)			
	0	4	8	12
60	240			
70	200			
80	165	202	231	
90	133	166	191	208
100	106	137	159	173
110	84	114	131	144
120	68	94	108	120
130	56	79	91	99
140	47	67	77	84
150	41	57	66	72
160	36	49	57	63
170	32	42	51	56
180	29	37	45	50
190	26	33	40	44
200	23	29	37	40

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 9
60% OXYGEN

showing bottom time in minutes at various depths to 200 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes) 0	4	8	12
80	211			
90	178	218		
100	148	182	210	228
110	122	154	178	194
120	99	129	150	164
130	80	110	126	140
140	67	93	107	118
150	57	80	91	100
160	49	69	79	86
170	43	60	68	75
180	38	52	60	67
190	34	45	54	59
200	31	40	49	53

APPENDIX B

THEORETICAL
NITROGEN-OXYGEN MIXED-GAS
DECOMPRESSION TABLES

TABLE 10
21% OXYGEN

showing bottom time in minutes at various depths to 170 feet for zero-, four-, eight-, and twelve-minute decompression time at the ten-foot stop after ascent at 25 feet a minute or less

DEPTH feet	SINGLE-STAGE DECOMPRESSION TIME (minutes)			
	0	4	8	12
40	119	151	175	190
50	79	108	125	138
60	56	79	91	99
70	43	60	68	75
80	35	46	54	60
90	29	36	44	49
100	24	29	37	40
110	20	25	32	34
120	17	21	27	29
130	15	18	23	25
140		15	20	22
150			17	19
160				17
170				15

APPENDIX B

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13. ABSTRACT

This report presents a brief of the basic theory of nitrogen-oxygen mixed-gas decompression, and gives the methods used to calculate the theoretical tables:

(1) For each 5% increment from 20% to 60% oxygen.
(2) For 4-minute increments from 0 to 12 minutes of single-stage decompression time.
(3) For 1-minute increments from 15 to 240 minutes of diving bottom time.

Appendix A to the report shows as typical IBM tabulation sheet for the calculations. Appendix B gives the nitrogen-oxygen decompression tables extracted from the IBM tabulations.

The report draws the following conclusions:

(1) The tables should provide adequate decompression.
(2) The tables should be substantiated by a controlled series of dives.

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